Project Status Report

High End Computing Capability
Strategic Capabilities Assets Program

11 December 2011

Dr. Rupak Biswas – Project Manager
NASA Advanced Supercomputing (NAS) Division
NASA Ames Research Center, Moffett Field, CA
Rupak.Biswas@nasa.gov
(650) 604-4411

Pleiades Vital to Understanding the 'Crack' in Earth's Magnetosphere

- Researcher Homa Karimabadi, University of California, San Diego, is running complex simulations on the Pleiades supercomputer utilizing over 18,000 cores to help understand the causes and conditions under which solar winds can penetrate (crack) Earth's magnetosphere.
- This crack affects Earth and its technological systems and has caused over $4 billion in satellite losses alone.
- The project has used simulations with over 3 trillion particles to study the microphysics of the magnetic reconnection process, and to examine the large-scale development of magnetic reconnection.
- Researchers have discovered blowing rings caused by electron vortices that contribute to the crack in the magnetosphere, and confirmed several predictions through comparison with spacecraft observations.
- Pleiades has been crucial to the project's breakthrough studies and is enabling closure on critical issues in magnetospheric physics.

Mission Impact: The enormous computational capabilities delivered by HECC resources are critical to enabling breakthrough research for projects within NASA's Science Mission Directorate.

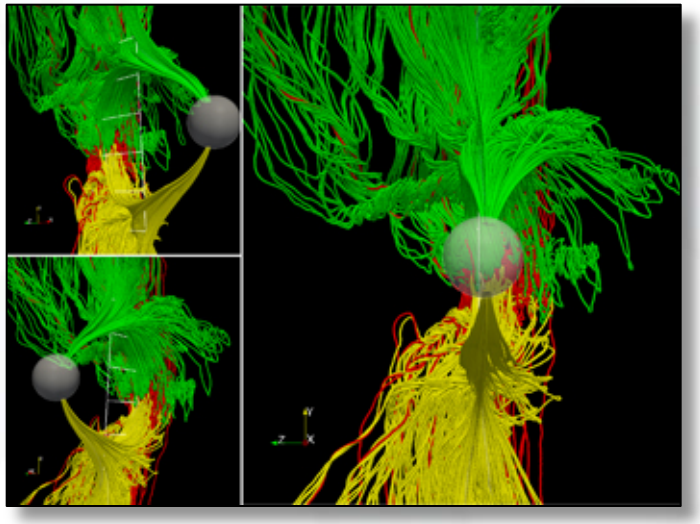


***Figure**:* Images from a 3D global hybrid simulation of the Earth's magnetosphere show the formation of large-scale magnetic flux ropes. These flux ropes are a direct consequence of the reconnection process that enables the solar wind to penetrate into the magnetosphere. Homa Karimabadi, University of California, San Diego; Burlen Loring, University of California, Berkeley.

***POC:** Homa Karimabadi, homa@eng.ucsd.edu, University of California, San Diego/SciberQuest, Inc.*

High-Fidelity Simulation of Rotorcraft Wakes Enabled by HECC Resources

- NASA Advanced Supercomputing Division researchers are developing physics-based computational tools to more accurately predict rotorcraft flowfields.
  - For the first time, the figure of merit (a measure of rotor blade efficiency) for a V-22 Osprey rotor in hover was predicted within experimental error using finer body grids, high-order spatial accuracy, and an improved turbulence model with detached eddy simulation.
  - A new, dynamic mesh refinement algorithm was used to improve resolution of rotor tip vortices by a factor of four, revealing turbulent vortical "worms" formed through entrainment of blade wake shear layers into tip vortices.
  - Computational fluid dynamics simulations of a UH-60 Blackhawk helicopter rotor in forward flight improved prediction of rotor normal forces and pitching moments by 50%.
- Solutions were obtained using 1,536 cores on the Pleiades supercomputer, which enabled completion of baseline grid solutions in less than a day, and completion of adaptive mesh refinement solutions in one week.

Mission Impact: Use of the Pleiades supercomputer allows researchers to dramatically enhance the accuracy of simulations to help increase rotorcraft performance and reduce the amount of noise that they produce.

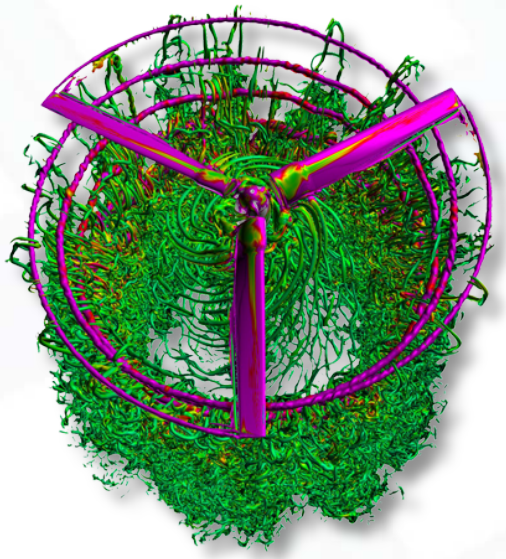


Figure: Navier-Stokes simulation of a V-22 Osprey rotor in hover, using adaptive mesh refinement (AMR) and the Spalart-Allmaras/ detached eddy simulation (DES) turbulence model. Vortices are rendered with the q-criterion. Magenta indicates high vorticity, blue indicates low vorticity. Neal Chaderjian, NASA/Ames.

POCs: *Neal Chaderjian, neal.chaderjian@nasa.gov, (650) 604-4472, NASA Advanced Supercomputing Division*

Tape Library Upgrade Nearly Triples Data Storage Capacity

- The HECC Systems team achieved the installation and integration of six new 8-frame Spectra Logic T-950 libraries two weeks ahead of the scheduled completion date.
- The new libraries hold about three times the number of tapes as the current library, providing nearly 60,000 tape slots to support the expanded capability of the Pleiades supercomputer.
- The total tape storage capacity for uncompressed data will approach 90 petabytes, up from about 31 petabytes.
- The major components in the new library are compatible with the next-generation library, which allows for cost-effective, in-place upgrades.

Mission Impact: To keep pace with the expanded computational capability of the Pleiades supercomputer, increased archive storage space is needed to enable researchers to save and re-analyze the results of their massive computations.

Figure: Top photo shows three of the new 8-frame libraries installed in N258. The bottom picture shows the internal workings of one of the libraries. Each media frame can hold 130 TeraPacks which each contain 10 LTO-5 1.5 TB cartridges.

POC: *Bob Ciotti, bob.ciotti@nasa.gov, (650) 604-4408, NASA Advanced Supercomputing Division; Davin Chan, davin.chan@nasa.gov, (650) 604-3613, NASA Advanced Supercomputing Division, Computer Sciences Corp.*

Network Infrastructure Augmentation Completed Successfully

- The HECC Network team successfully expanded the network infrastructure of both the main computer room at the NASA Advanced Supercomputing (NAS) facility and the remote computer room across the center at Ames to support the installation of the new Spectra Logic tape libraries (slide 5).
- Installation of a new network cabinet and two subfloor enclosures provides a centralized and manageable Fibre Channel solution for the tape libraries. The team also installed four 96-strand fiber trunks, relocated and installed four Fibre Channel switches, and installed 325 patch cables to provide network connectivity to the new tape libraries.
- The flexibility of the network infrastructure enables faster, cost-effective augmentations as HECC network infrastructure requirements evolve.

Mission Impact: Augmentation to the HECC network infrastructure provides enhanced connectivity and flexibility for new tape libraries and allows for the support of future computational expansion on the computer room floor.

Figure: New network cabinet and subfloor enclosure box housing the mass storage Fibre Channel infrastructure located in the main computer room at the NAS facility.

POC: *Chris Buchanan, chris.buchanan@nasa.gov, (650) 604-4308, NASA Advanced Supercomputing Division*

Webinar Series Focuses on Effective Use of HECC Resources

- HECC's Application Performance and Productivity (APP) group initiated a sequence of web-based training sessions (webinars) on a variety of topics of interest to the user community.
- The initial presentation, targeted at new users from the NAS Operational Period (NOP), was an orientation about effectively utilizing HECC resources.
- This first webinar was held on November 9, 2011.
- These webinars are held once a month and recorded for on-demand playback over the web.
- The widespread locations of the 10 attendees (3 local, 2 in Los Angeles, 1 each in Montana, Texas, Ohio, Virginia, and North Carolina) demonstrate the usefulness and cost-saving nature of this approach for conducting user training.
- The next two webinars slated for December 2011 and January 2012 are: "Where should I Run my Job? and "I/O: Tips and Techniques," respectively.

Mission Impact: Providing web-based training sessions on best practices for utilizing HECC resources allows users from mission directorates to make more effective use of the systems, thus having a direct impact on their project milestones.

Figure: Slides from the presentation," New User Orientation." the first in an ongoing user training series.

POC: *Piyush Mehrotra, piyush.mehrotra@nasa.gov (650) 604-5126; Robert Hood, robert.hood@nasa.gov (650) 604-0740, NASA Advanced Supercomputing Division, Computer Sciences Corp.*

NASA Science & Engineering High-End Computing Results Highlighted at SC11

- HECC led the Agency's successful presence at SC11, the International Conference for High-Performance Computing, Networking, Storage, and Analysis, held in Seattle, November 12–18.
- Scientists and engineers from 6 NASA centers and several universities demonstrated 40 projects from all technical Mission Directorates, enabled by Agency supercomputers.
- Featured were talks on the Kepler mission's search for Earth-size planets, modeling and simulation for the Space Launch System design, computational tools to improve prediction of rotorcraft flowfields, and simulations to better understand the causes of space weather.
- This year HECC provided new ways for visitors to quickly and easily get information on the Agency's SC11 activities, including a mobile website, iPads at the information desk linking to NASA's SC11 website, and QR codes linking to information on each project, and an electronic scheduling board.

Mission Impact: The SC11 conference provides an opportunity for wider information dissemination of NASA accomplishments among multiple agencies, companies, and academic institutions.

Figure: At top, the NASA SC11 team in NASA's 30-ft.-by-50-ft. booth. At bottom, presenters interact with visitors in the booth.

POC: *Gina Morello, gina.f.morello@nasa.gov, (650) 604-4462, NASA Advanced Supercomputing Division*

Systems Team Demonstrates New InfiniBand Network Capability at SC11

- At SC11, HECC Systems team members, in partnership with Lawrence Livermore National Laboratory (LLNL) and Obsidian Strategics, demonstrated a geo-distributed two-subnet InfiniBand fabric that spanned LLNL to NASA Ames using a next-generation InfiniBand subnet manager known as BGFC.
- Subnet managers available today only support a single subnet InfiniBand network, presenting a challenge to manageability, scalability, and reliability of networks.
- The demonstration showed InfiniBand traffic passing at wire speeds with Advanced Encryption Standard encryption between LLNL's Hyperion cluster and a rack of Pleiades nodes; this demonstration was notable, as it combined both Clos (Fat-Tree) and Hypercube subnets into a single fabric.

Mission Impact: By collaborating with other high-performance computing (HPC) sites and industry partners, the HECC project is able to influence the direction and specifications of solutions to best meet the needs of the NASA mission directorates as well as support the larger HPC community.

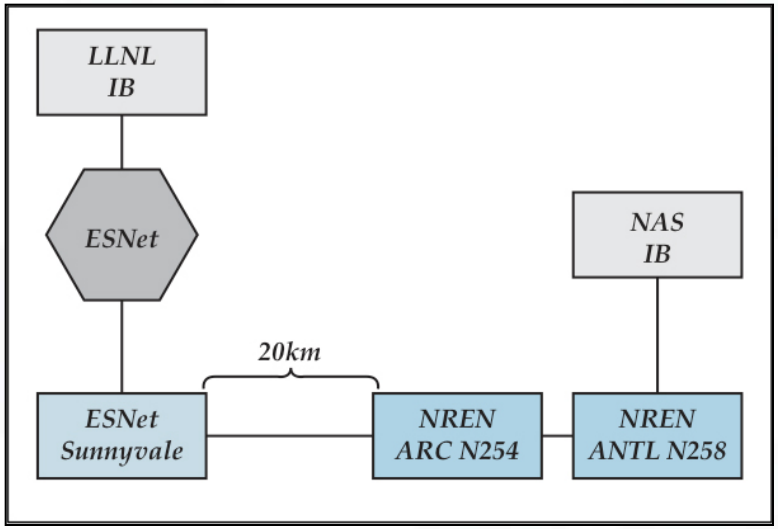


Figure: The chart above shows the network topology of the connectivity between NASA Ames and Lawrence Livermore National Laboratory used during the demonstration for the SC11 Conference.

POC: *Bob Ciotti, bob.ciotti@nasa.gov, (650) 604-4408, NASA Advanced Supercomputing Division; Davin Chan, davin.chan@nasa.gov, (650) 604-3613, NASA Advanced Supercomputing Division, Computer Sciences Corp.*

HECC Visualization Support Recognized During SC11 Conference

- At the SC11 conference in Seattle (see slide 8), hyperwall-2, developed by the HECC Visualization team, was recognized and featured by both the high-performance computing community and NASA's Public Affairs Office.
- At the conference, HPCwire announced that the hyperwall-2 won the HPCwire People's Choice Award for best visualization system.
- The annual awards are highly coveted as prestigious recognition of achievement by the HPC peer community.
- The 128 node hyperwall-2 cluster enables scientists to visualize some of the largest datasets generated on the Pleiades supercomputer.
- An image created by the team to support a featured SC11 project on using CFD to improve rotorcraft performance was featured as NASA's image of the day. See: http://www.nasa.gov/multimedia/imagegallery/image_feature_2108.html

Mission Impact: Visualization technologies, displays, and software, along with the capability of the Pleiades supercomputer, enhance engineering decision support and scientific discovery for all NASA mission directorates.

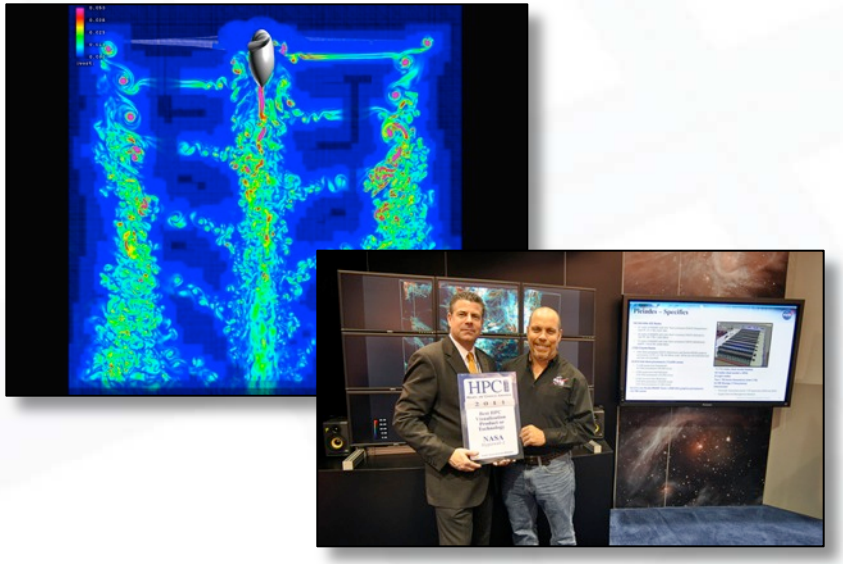
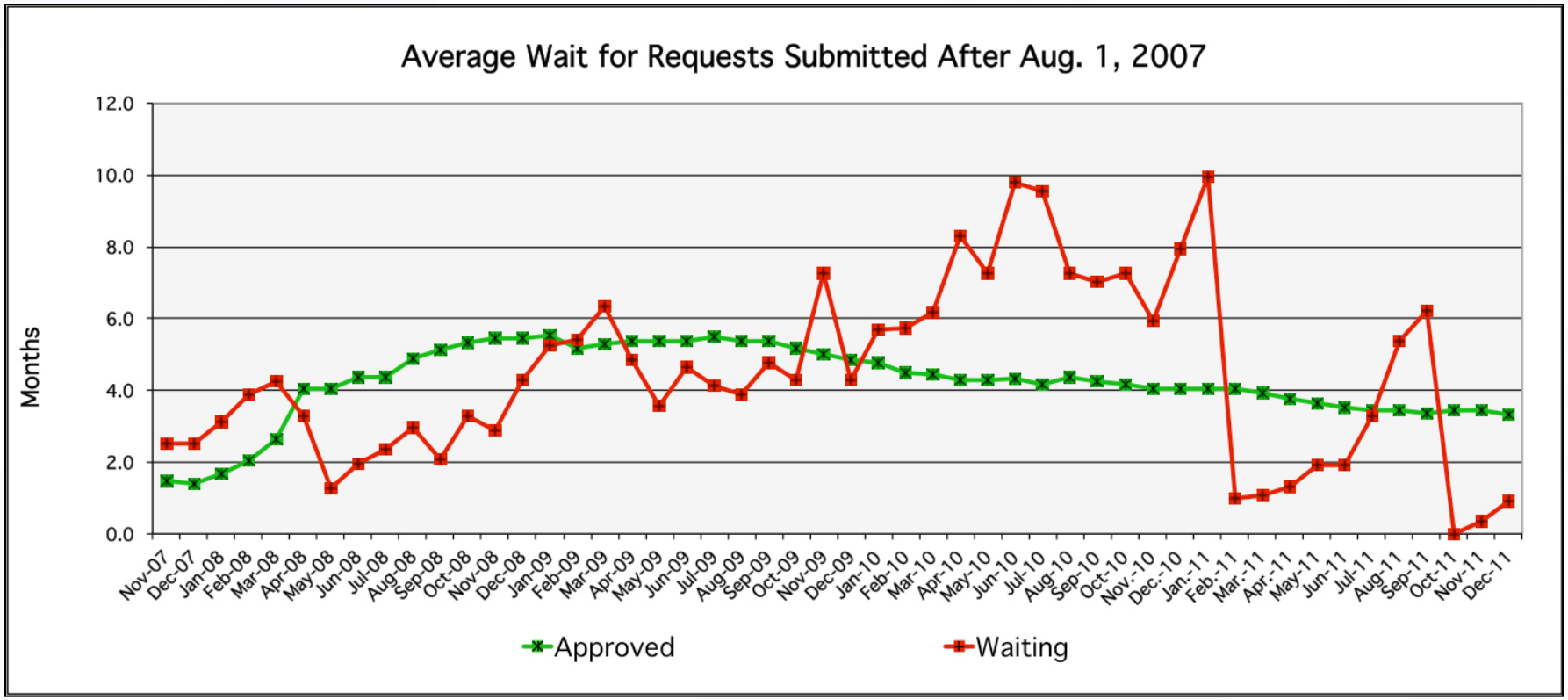


Figure: At top, the selected NASA Image of the Day illustrates how supercomputing and visualization resources and services help NASA develop faster and quieter rotorcraft with larger lifting capability. At bottom, HECC Visualization team member Tim Sandstrom (right) accepts the hyperwall-2 award for best visualization system from HPCwire editor Tom Tabor.

POC: *Tim Sandstrom, timothy.a.sandstrom@nasa.gov, (650) 604-1429, NASA Advanced Supercomputing Division, Computer Sciences Corp.*

Status of Requests for NAS Computer Accounts by non-U.S. Citizens

- Requests approved: 9; New requests received: 14; Requests waiting: 7.
- Wait times are between 0.7 and 1.4 months.
- The International Visitor Control Center has been contacted for updates on those who have been waiting more than one month.



HECC Facility Hosts Several Visitors and Tours in November 2011

- HECC hosted 4 scheduled tour groups in November; guests received an overview of the HECC Project, demonstrations of the hyperwall-2 visualization system, and tours of the computer room floor. Guests this month included:
- Two groups of 30 conference attendees participating in Ames' Solar Dynamics Observatory Workshop, co-chaired by Nagi Mansour; attendees were shown various solar studies on the hyperwall-2—some images were developed in collaboration with researchers in the audience.
- Attendees of the Ames Tech Expo were shown simulations of the the Space Launch System, launch environments, and engineering risk assessments projects.
- Gwang Hyeok Ju, Korea Advanced Research Institute (KARI), Yungjin Jung, KARI, and Sijeong Park, South Korean Ministry of Education, Science & Technology, visited the facility as VIP guests of Ames Center Director Pete Worden for possible future collaboration in Small Satellites programs.

Figure: As part of their Ames tours, guests visited NASA Advanced Supercomputing facility.

POC: *Gina Morello, gina.f.morello@nasa.gov, (650) 604-4462, NASA Advanced Supercomputing Division*

Presentations and Papers

- **SC11, Nov. 12–18, Seattle, WA**
  - *Panel Session*: “HPC in the Cloud–Clearing the Mist or Lost in the Fog,” F. Ron Bailey (Chair); Piyush Mehrotra (Panelist)
  - *Birds-of-a-Feather*: “Research Challenges and Funding Opportunities in HPC Clouds for Federal Agencies,” Bryan Biegel
  - *Tutorial*: “S13: HPC Archive Solutions Made Simple,” Matt Cary
  - Exhibitor Forum: “Novel & Future Architectures I,” Bill Thigpen
- “Performance Analysis of CFD Application Cart3D Using MPInside and Performance Monitor Unit Data on Nehalem and Westmere Based Supercomputers,” S. Saini, P. Mehrotra, K. Taylor, M. Aftosmis, R. Biswas, 13th IEEE International Conference on High Performance Computing and Communications, pp. 331-338, Sept. 2011 (online Nov 2011).* *http://ieeexplore.ieee.org/xpls/abs_all.jsp?arnumber=6063009*
- “Technologies for Large-Scale Numerical Simulation,” Bryan Biegel, NASA Tech Briefs Magazine, Nov 2011
- “Progress in Aeroelastic Computations Using Time-Accurate CFD/CSD Coupling,” Guru Guruswamy, 5th Symposium on Applied Aerodynamics & Design of Aerospace Vehicles, Nov 20 *
- “Simulation of Relativistic Jets and Assocaited Self-consistent Radiation,” K.-I. Nishikawa et al, Fermi Symposium conference proceedings, submitted Nov. 1, *http://arxiv.org/abs/1111.3622* *

** HECC provided supercomputing resources and services in support of this work*

News and Events

- **NASA Science, Technology Featured at Supercomputing Conference**, *official NASA press release,* Nov. 8, 2011 – Description of NASA exhibit and featured demonstrations, with quote from Rupak Biswas.
  http://www.nasa.gov/centers/ames/news/releases/2011/11-89AR.html
- **NASA and Partners to Demonstrate 40- and 100-Gigabit Network Technologies at SC11**, *NASA media alert,* Nov. 10, 2011 – Announcement of "Live, Real-Time Demonstrations of 40-to-100-Gbps File Transfers Across Wide-Area Networks," supported by HECC network staff at SC11.
  http://science.gsfc.nasa.gov/606.1/HECN-highlights/HECN_SC11_Net-Demo_announce_111011.html
- **NASA's Supercomputer Maintains Ranking, Supporting More Research**, *NASA media alert*, Nov. 15, 2011 – Announcement that the Pleiades supercomputer maintained its status as the seventh most powerful supercomputer in the world on the TOP500 list. Picked up by multiple media sources, including Information Week. *http://www.nasa.gov/centers/ames/news/releases/2011/11-92AR.html*
- **Supercomputing 2011 Ultimate Slideshow: NASA**, *News & Analysis Blog, Sylvie Barak*, *EE Times*, Nov. 25, 2011 – "For stargazers and scientists alike, the NASA booth was the place to be at SC11." Short description of NASA SC11 booth, with photos.
  http://www.eetimes.com/electronics-news/4230924/Supercomputing-2011-ultimate-slideshow-?pageNumber=9
- **Intel Processors Power The Majority of Top 500 Supercomputers, Looking to Expand With MIC Solutions**, *article, PC Perspective*, Nov. 25, 2011 – Mentions Pleiades among the most powerful supercomputers powered by Intel processors.
- **NASA supercomputer searches for sister planets**,*" feature story, Sylvie Barak, EETimes,* Dec. 1, 2011 – Covers SC11 Kepler mission info, with interview and video of Todd Klaus, and based on NASA media backgrounder by HECC writer Jill Dunbar.
  http://www.eetimes.com/electronics-news/4231061/NASA-supercomputer-searches-for-sister-planets
- **V-22 Rotorcraft Cross-Section**, *NASA Image of the Day item picked up by Scientific Computing and other media sources and blogs (see slide 10)*
  http://www.scientificcomputing.com/news-DA-V-22-Rotocraft-Cross-Section-120211.aspx

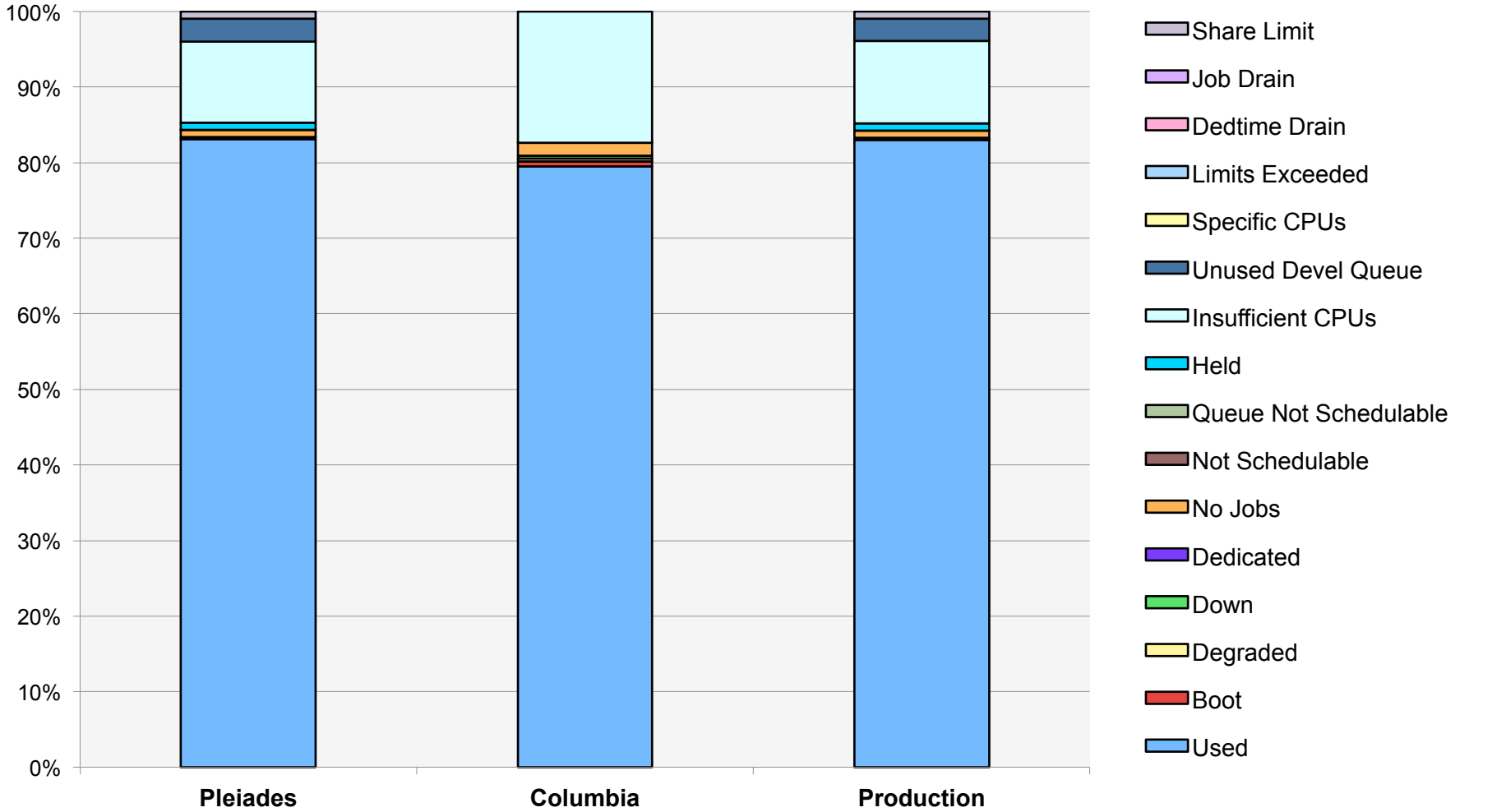
News and Events (cont.)

- **Apollo Zone Digital Image Mosaic and Digital Elevation Model Released**, *article, SpaceRef.com,* Nov. 24, 2011 – Map processing for NASA's Apollo Zone Digital Image Mosaic and Digital Elevation Model of the lunar surface was performed using the Pleiades supercomputer.
  http://www.spaceref.com/news/viewsr.html?pid=39167

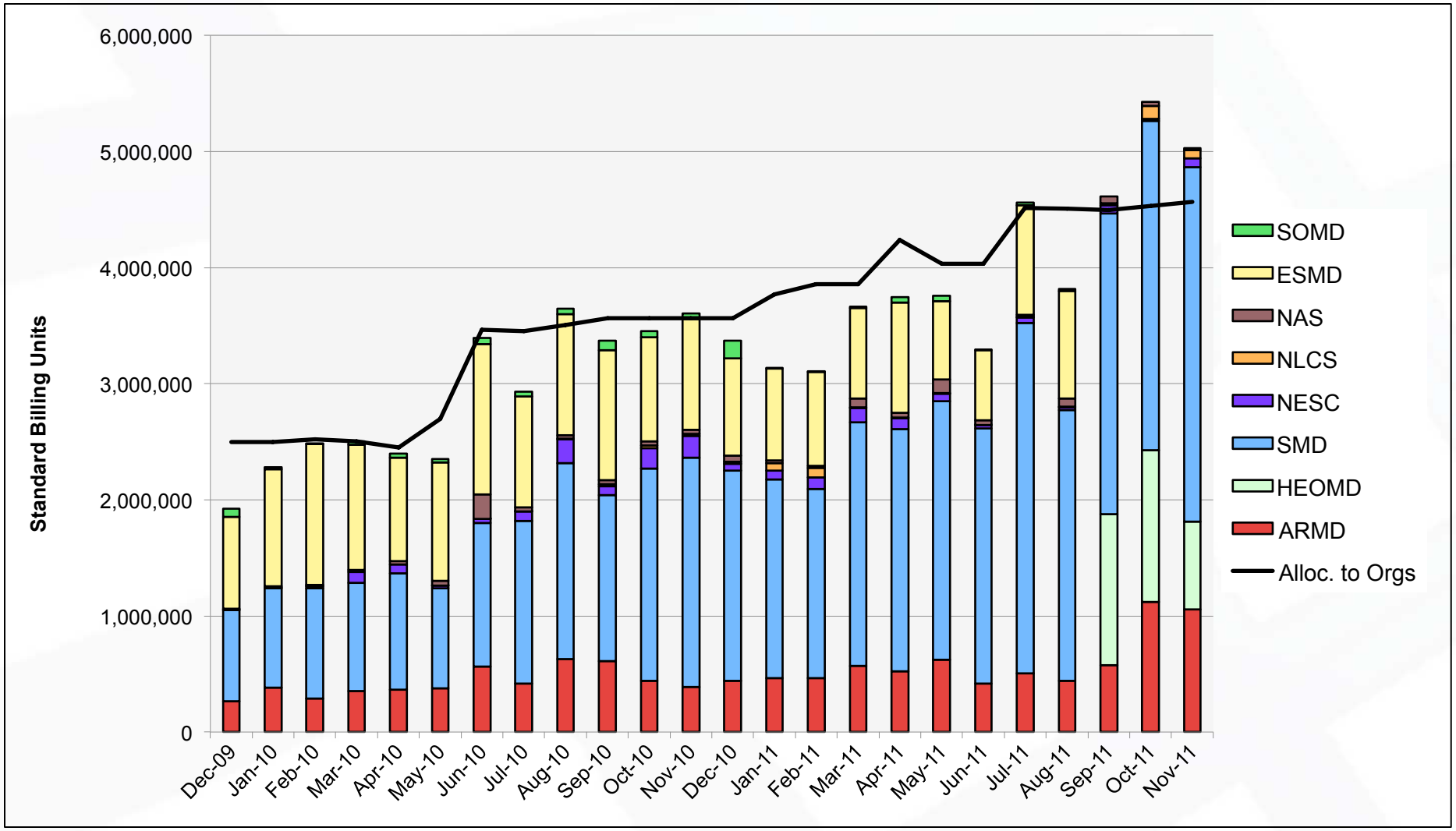
- **Roundup: Luxtera, SGI, NetApp, Cloudera**, *article, Data Center Knowledge,* Nov. 9, 2011 – Section on Pleiades upgrade in 2012 to ensure NASA customers get performance needed to "deliver on key multi-petascale workloads."
  http://www.datacenterknowledge.com/archives/2011/11/09/roundup-luxtera-sgi-netapp-cloudera/

- **NASA Selects Next-Generation SGI® ICE HPC Platform for Technology Upgrade**, *SGI press release,* Nov. 8, 2011 – Announcement that NASA selected its next generation SGI® ICE high performance computing (HPC) platform to extend the computational capability of NASA's Pleiades supercomputer.
  http://www.sgi.com/company_info/newsroom/press_releases/2011/november/nasa.html

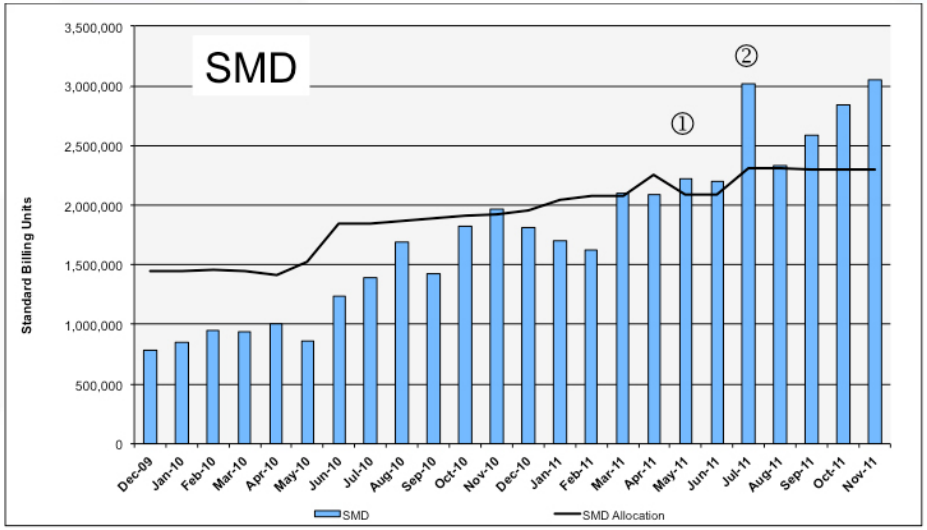
HECC Utilization

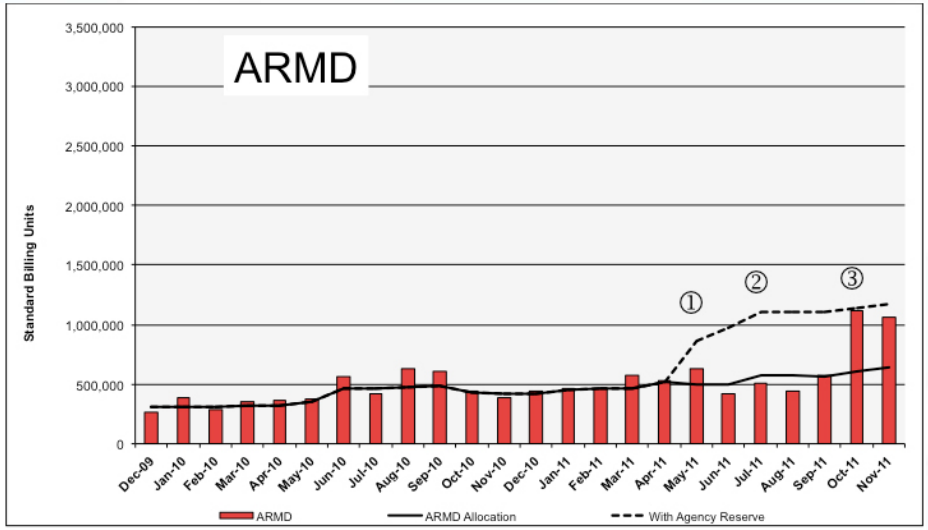


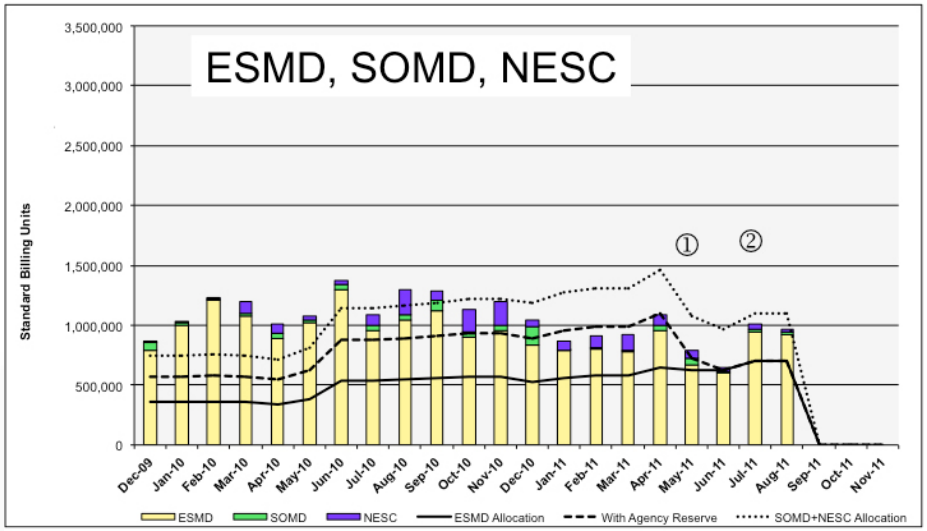
HECC Utilization Normalized to 30-Day Month

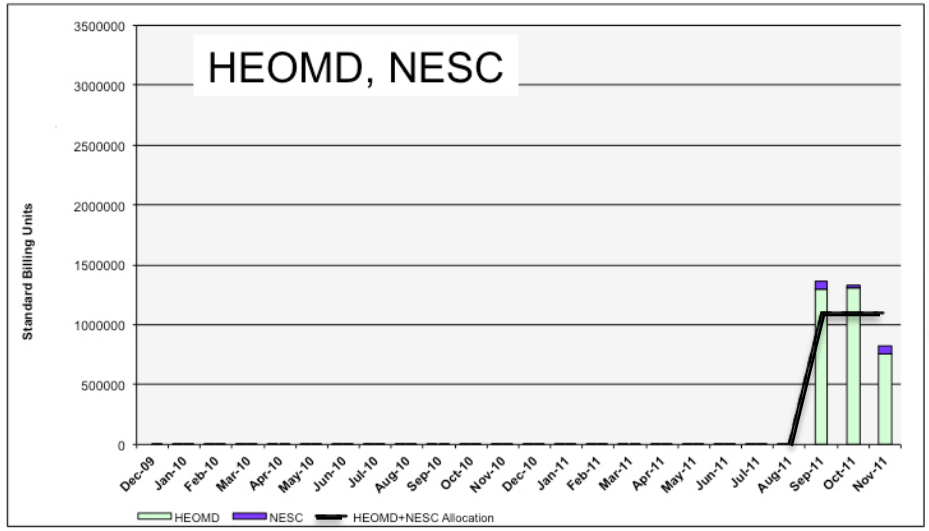


HECC Utilization Normalized to 30-Day Month



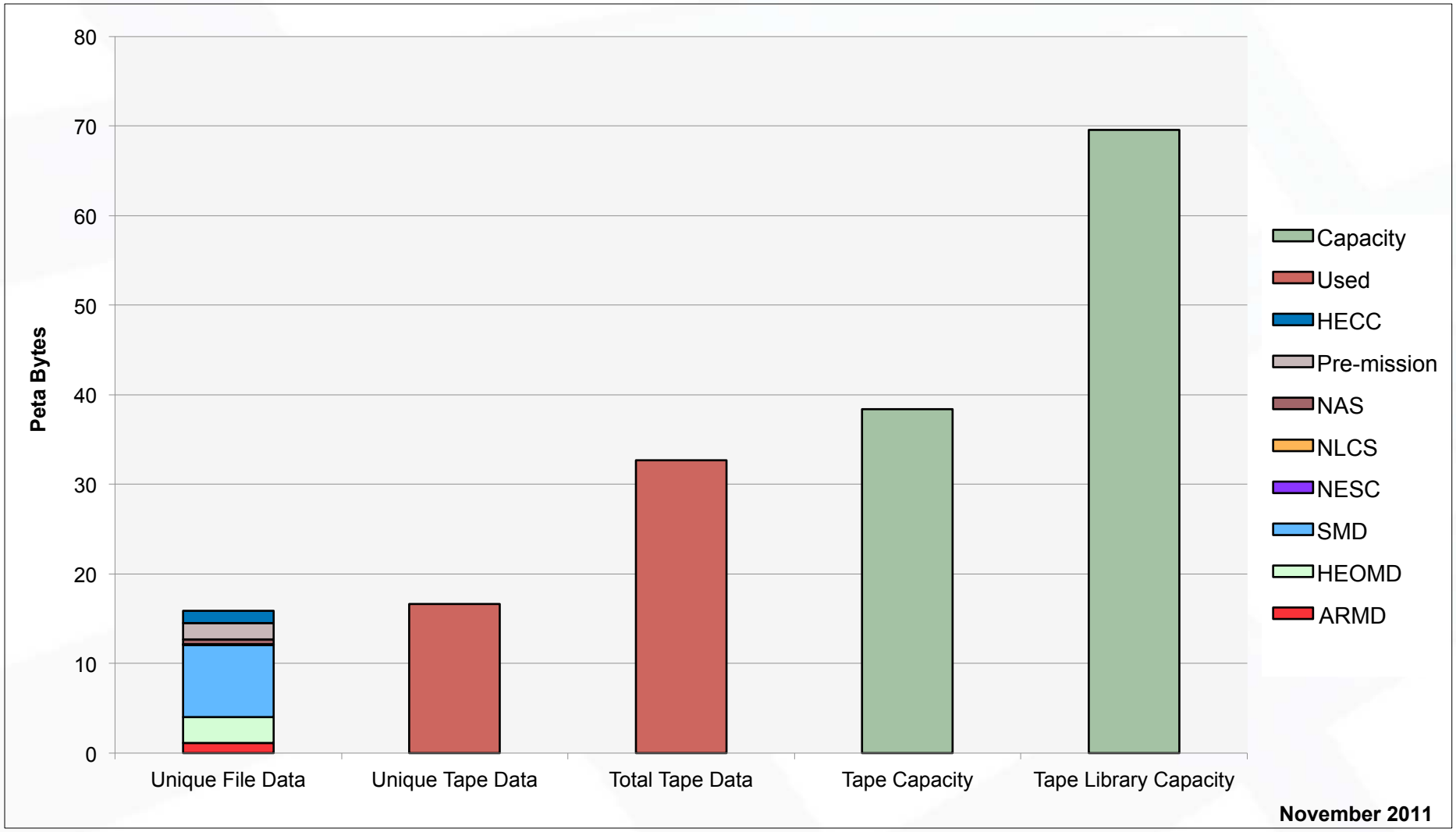




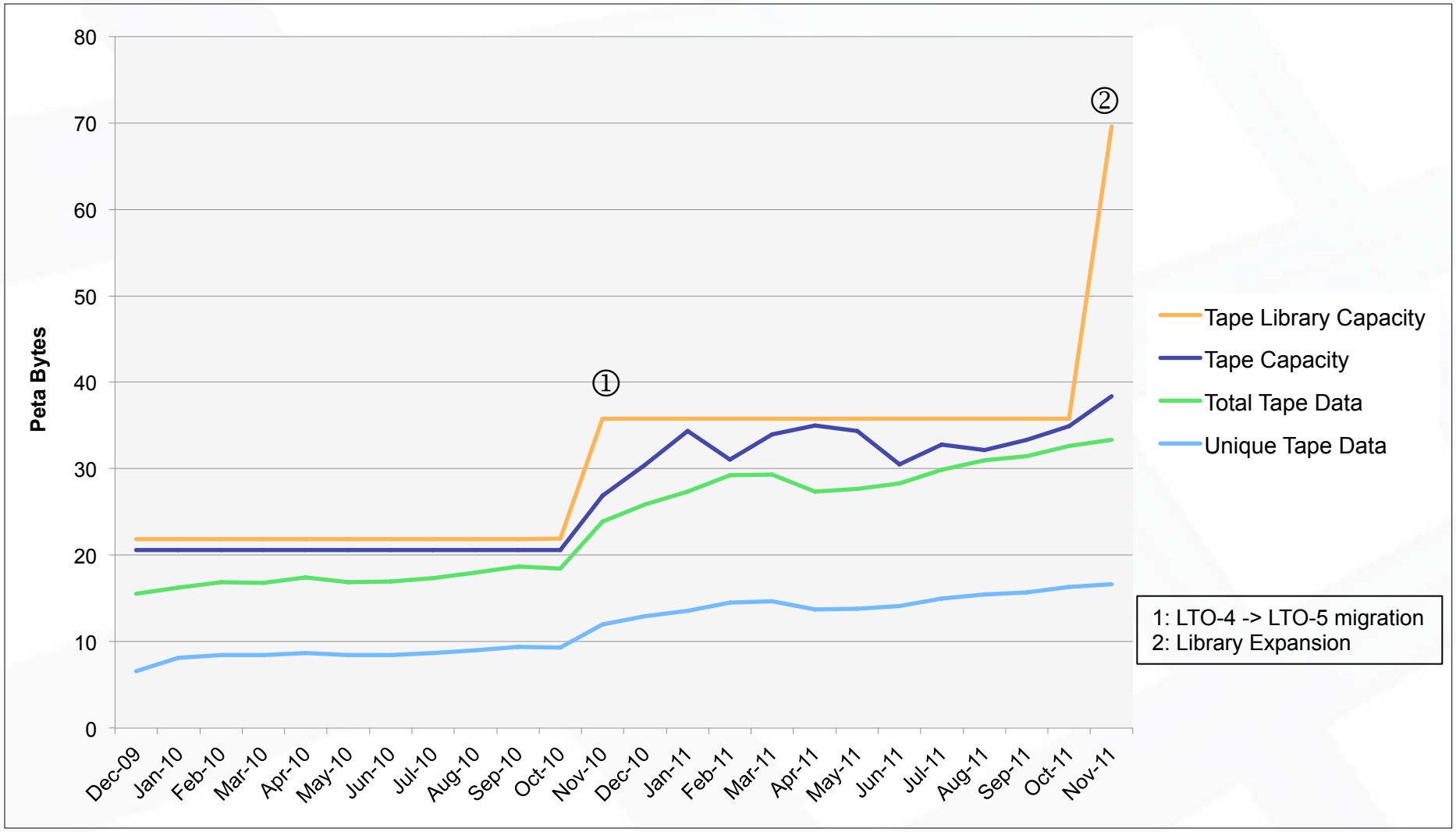


① Allocation to orgs. decreased to 75%, Agency reserve shifted to ARMD ② 14 Westmere racks added ③ 2 ARMD Westmere racks added

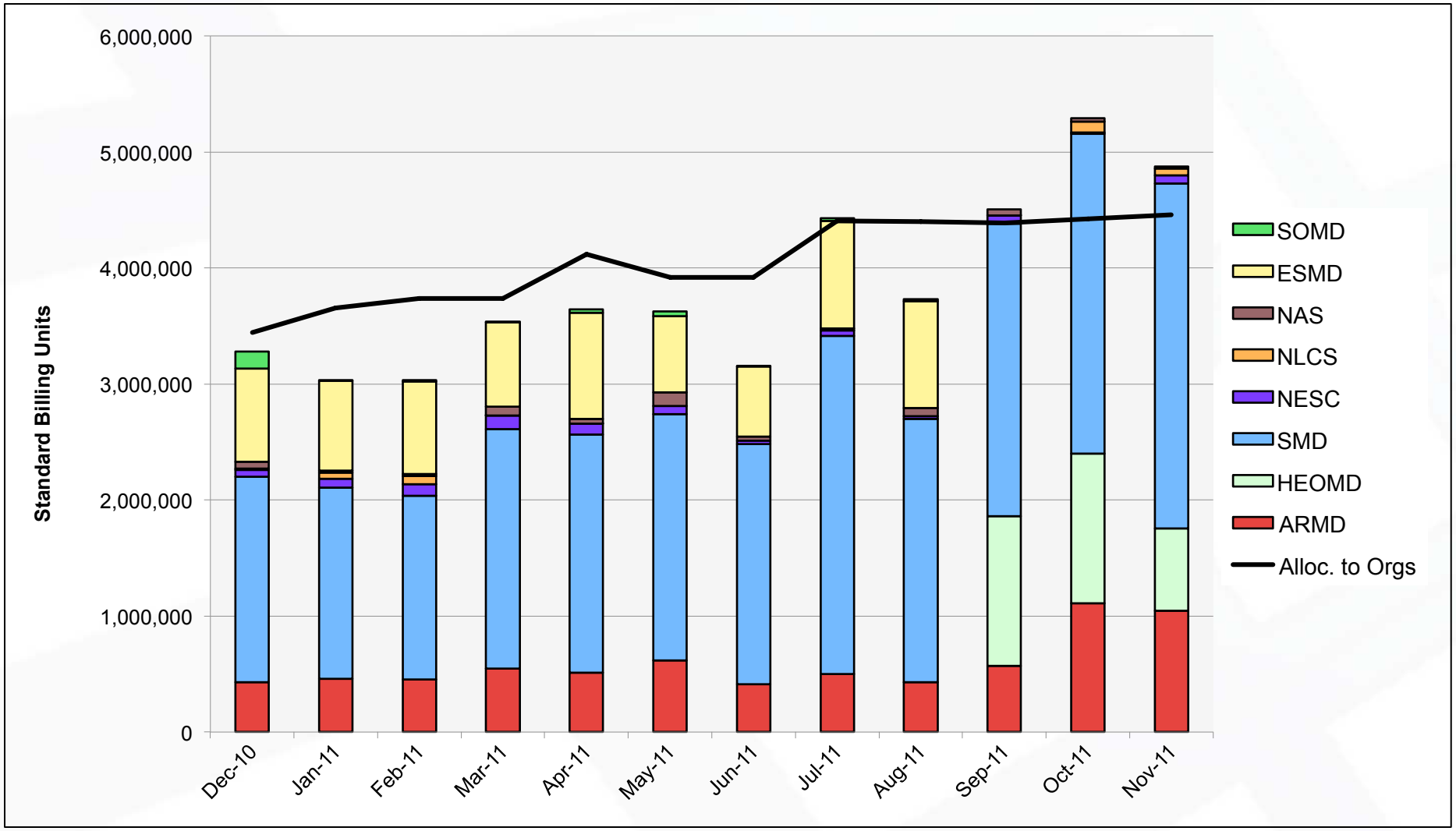
Tape Archive Status



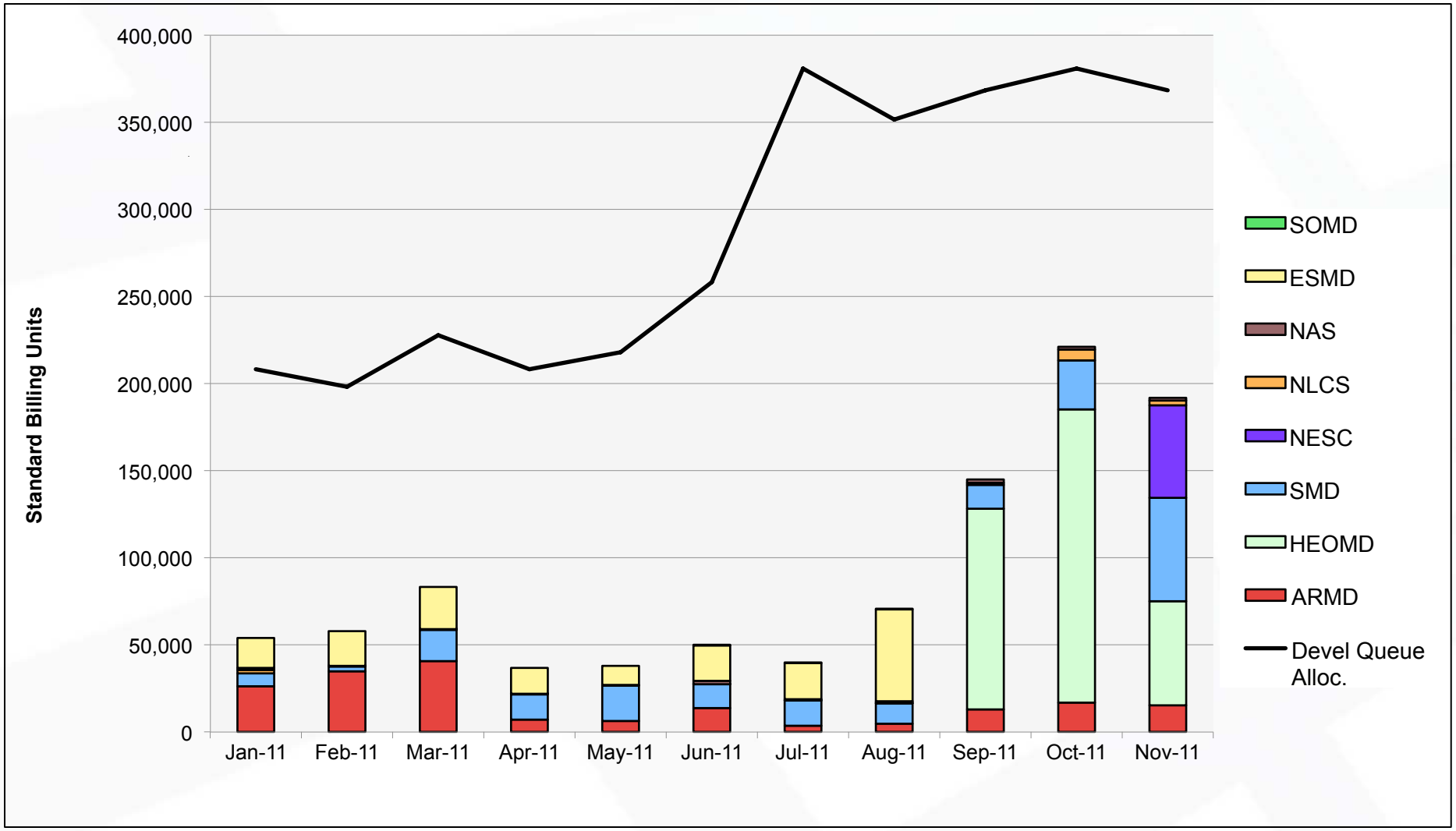
Tape Archive Status



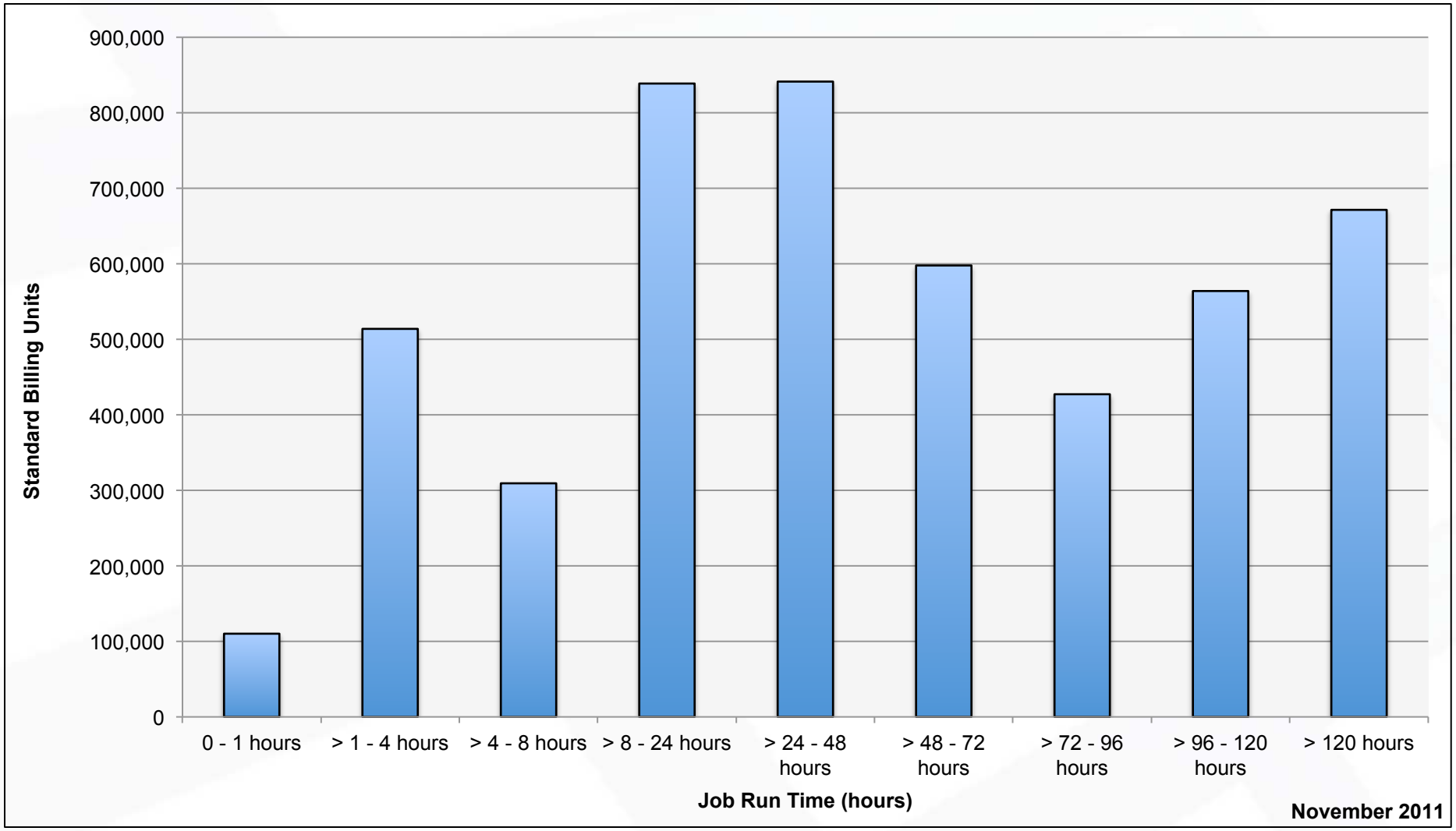
Pleiades:
SBUs Reported, Normalized to 30-Day Month



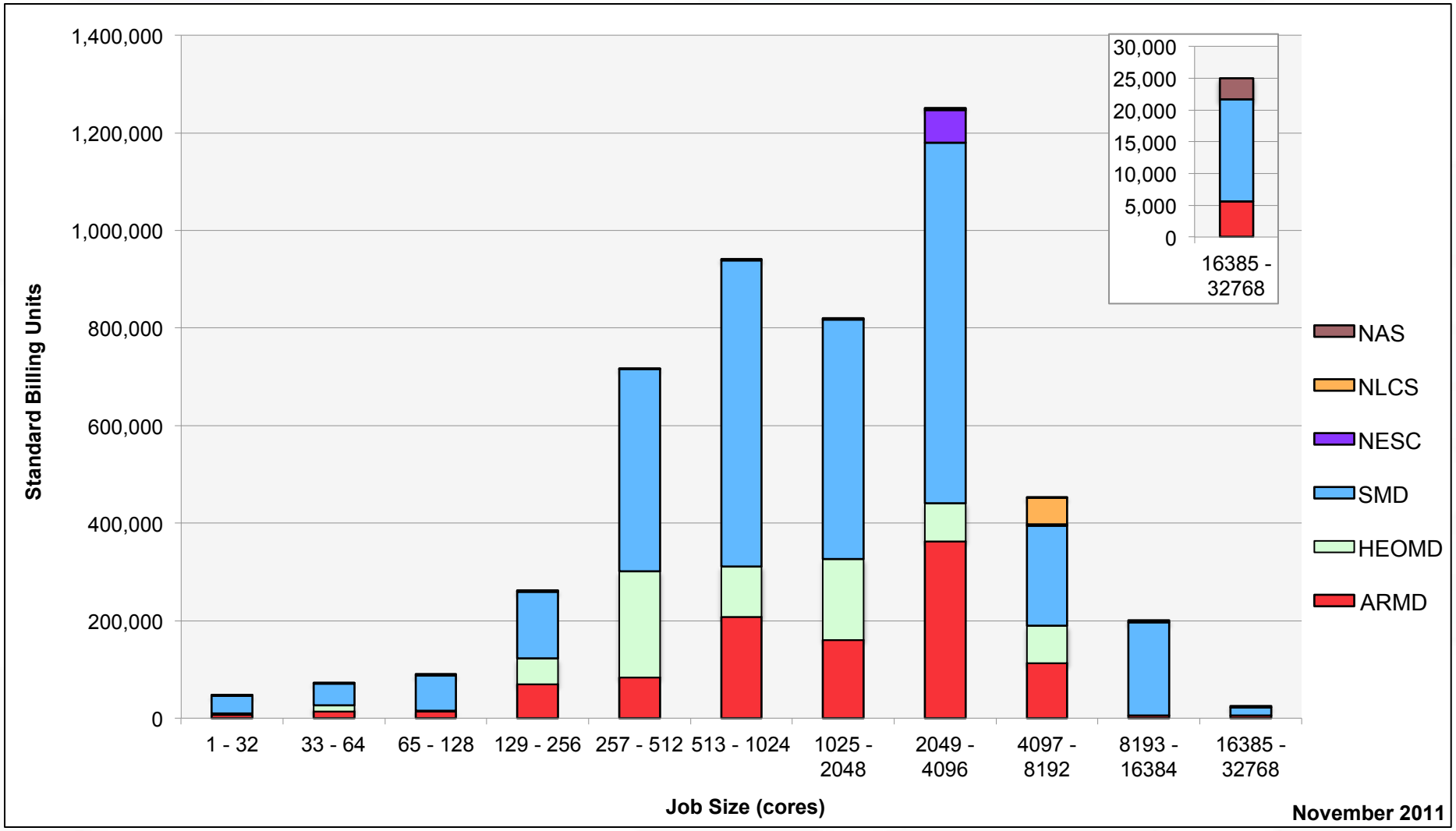
Pleiades:
Devel Queue Utilization



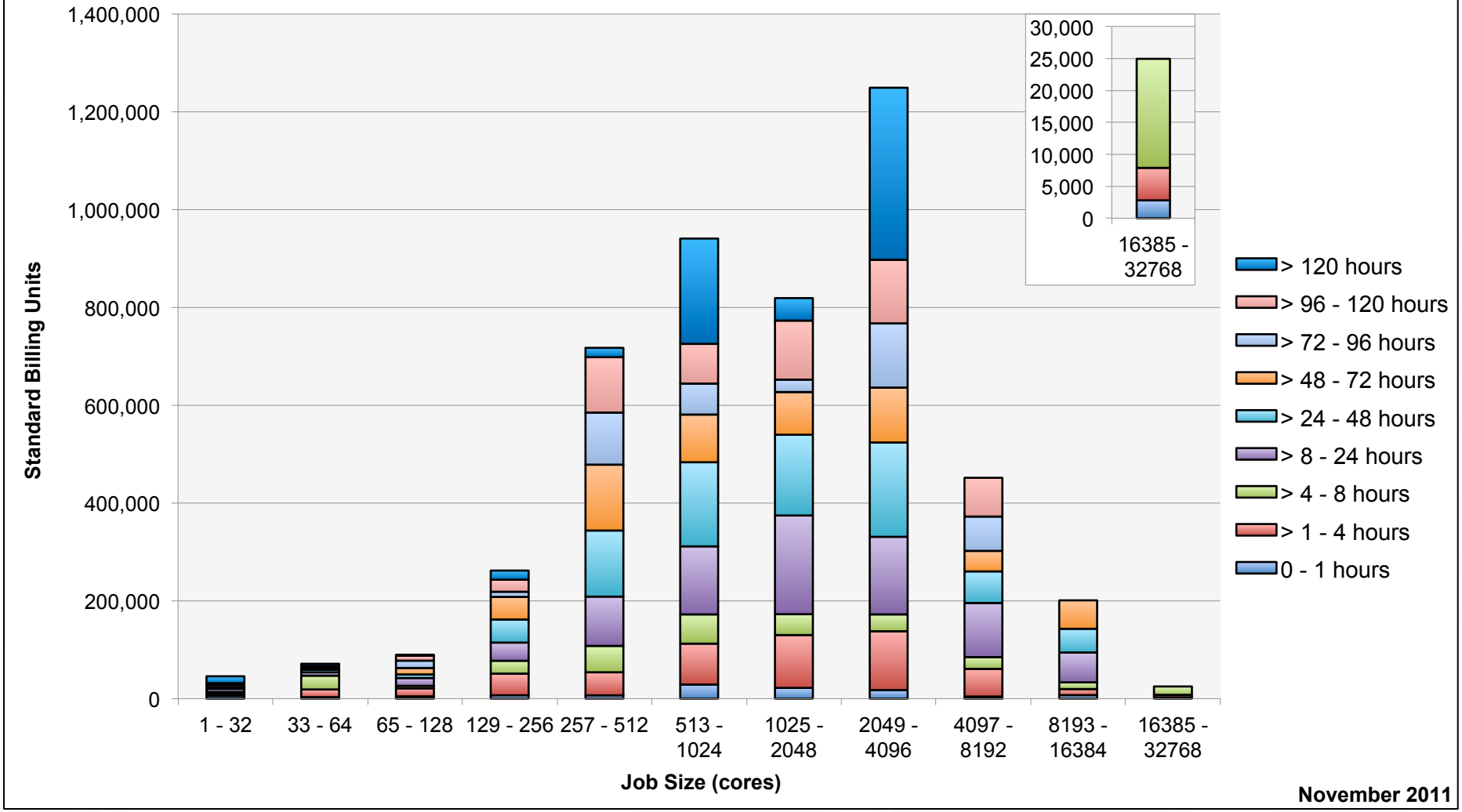
Pleiades:
Monthly SBUs by Run Time



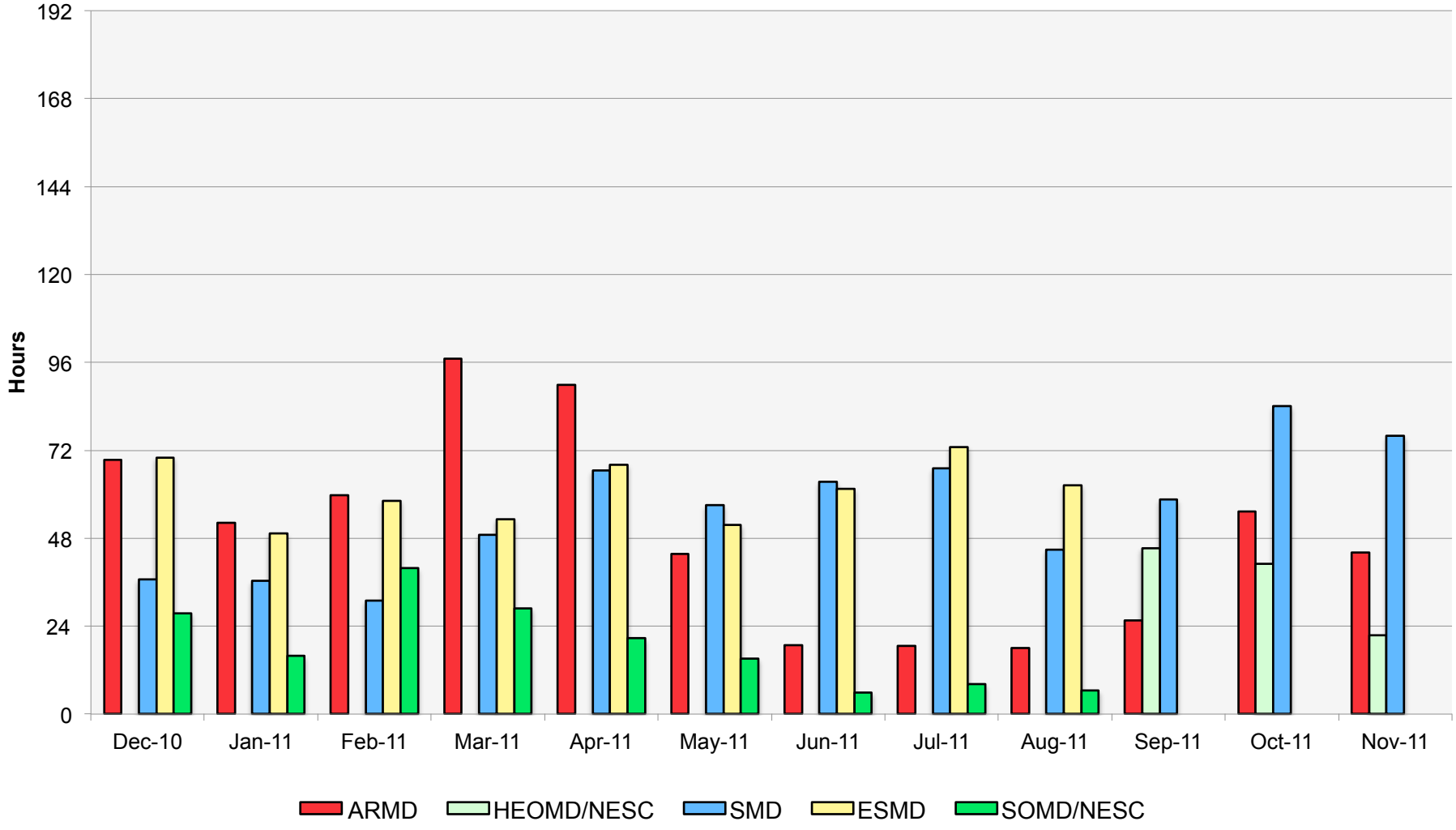
Pleiades:
Monthly Utilization by Size and Mission



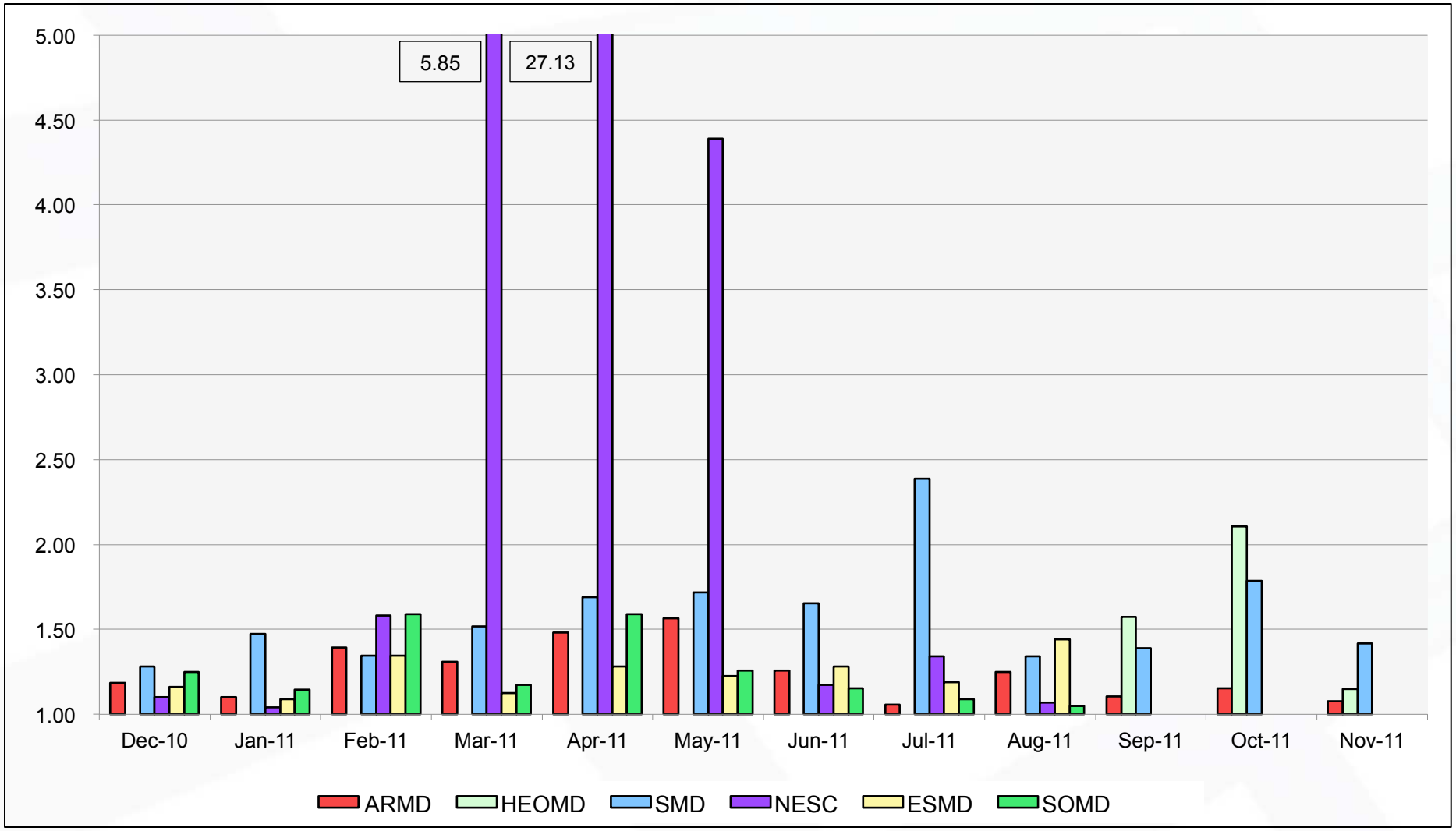
Pleiades:
Monthly Utilization by Size and Length



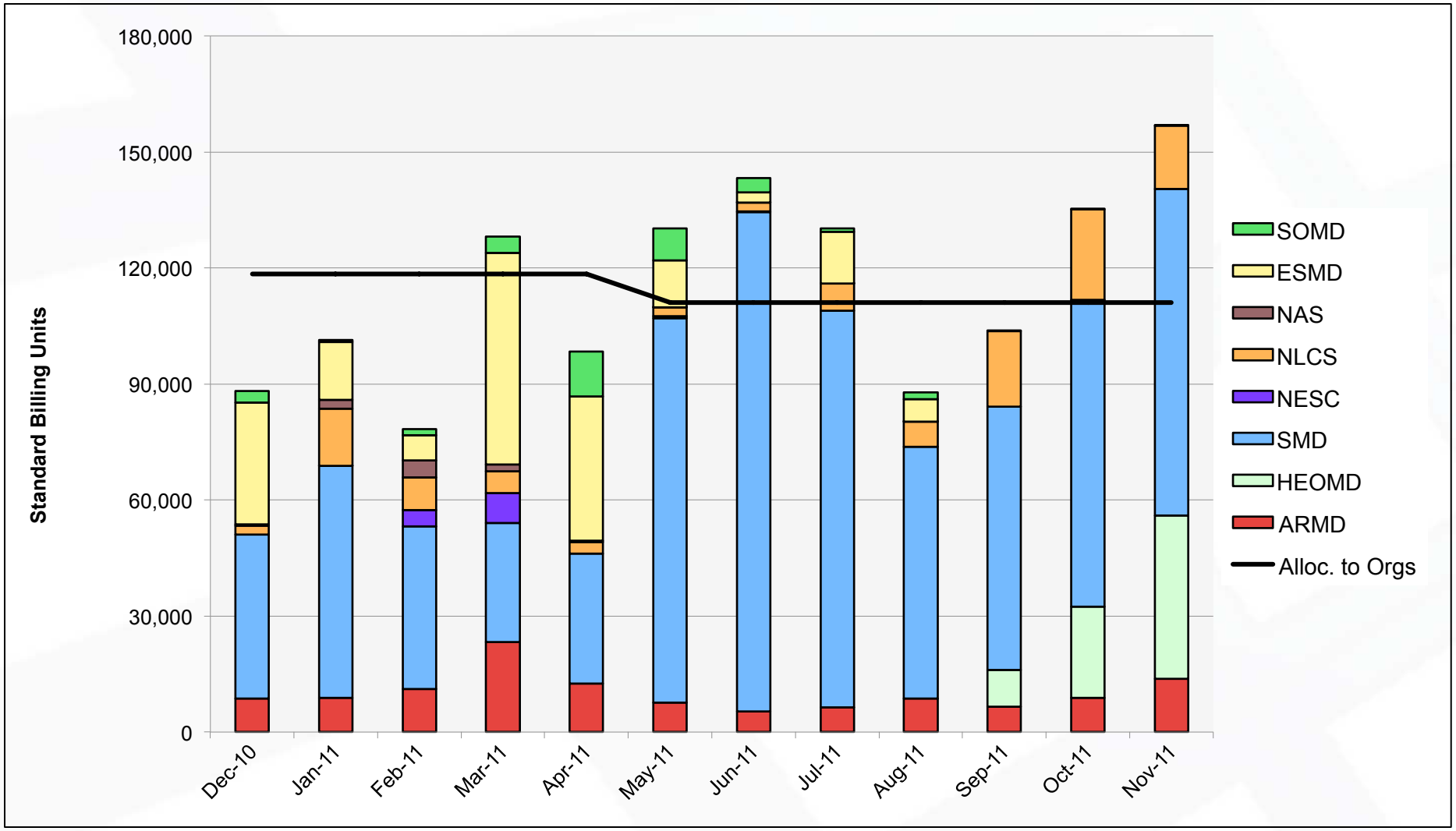
Pleiades:
Average Time to Clear All Jobs



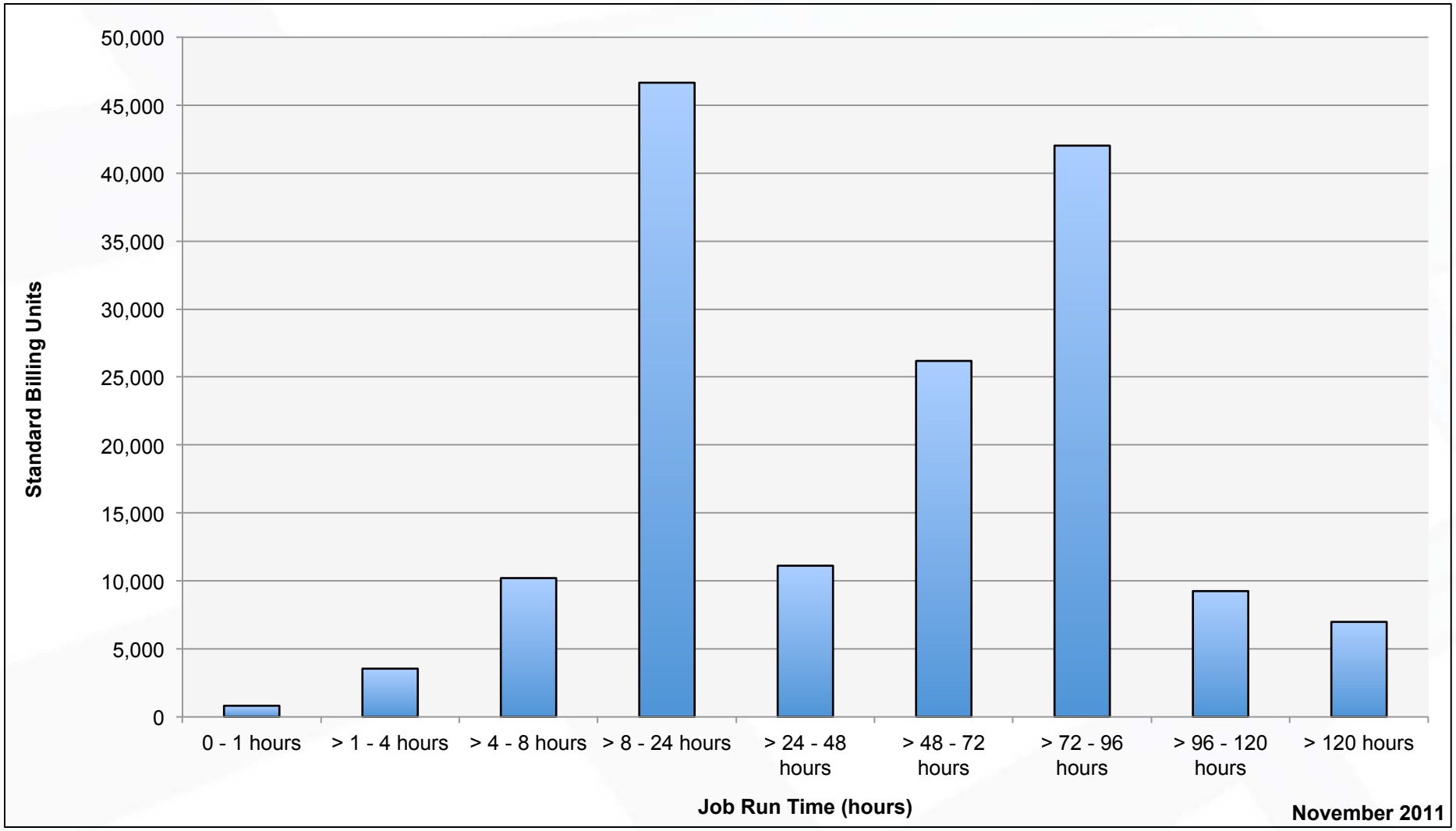
Pleiades:
Average Expansion Factor



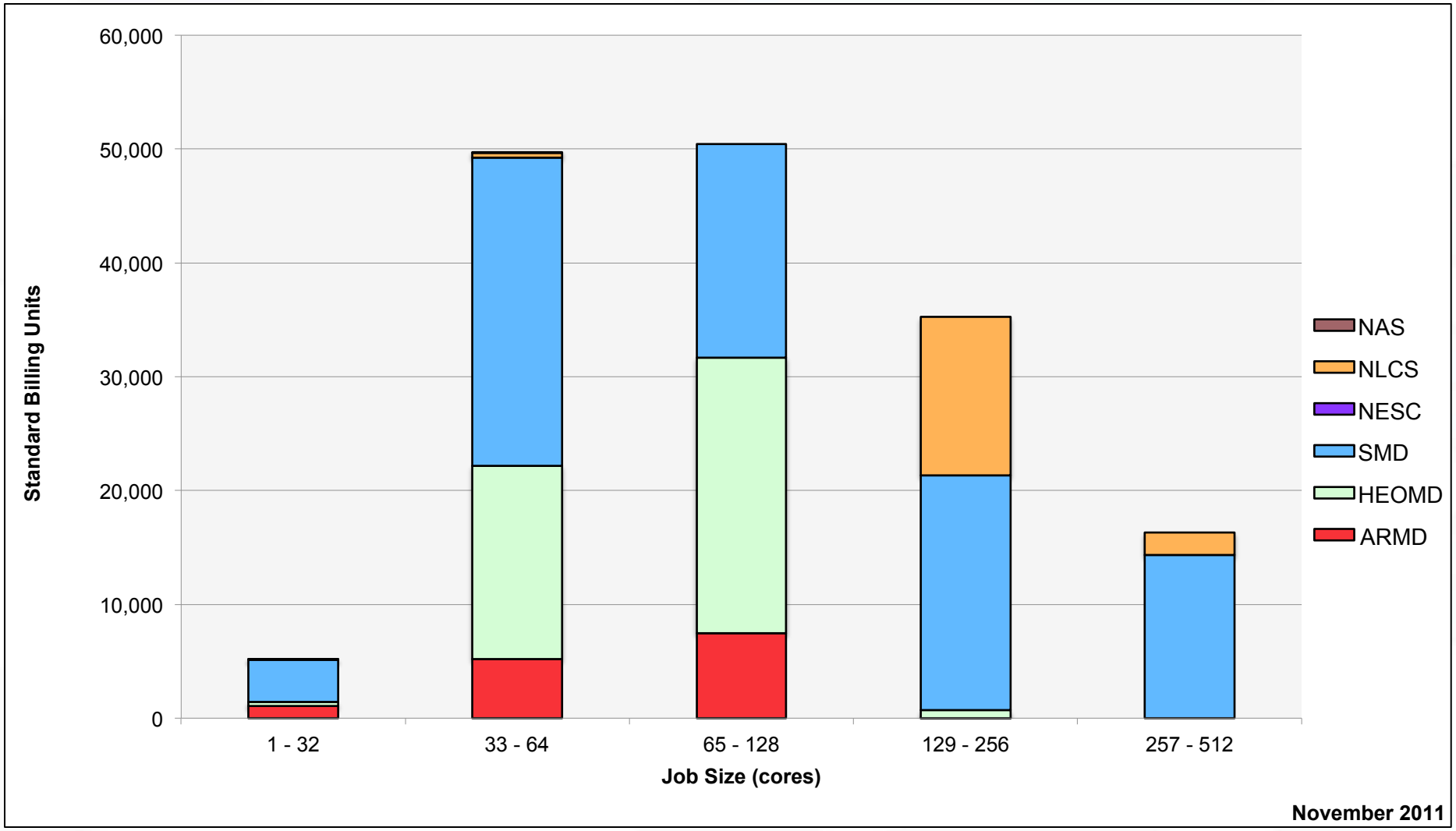
Columbia:
SBUs Reported, Normalized to 30-Day Month



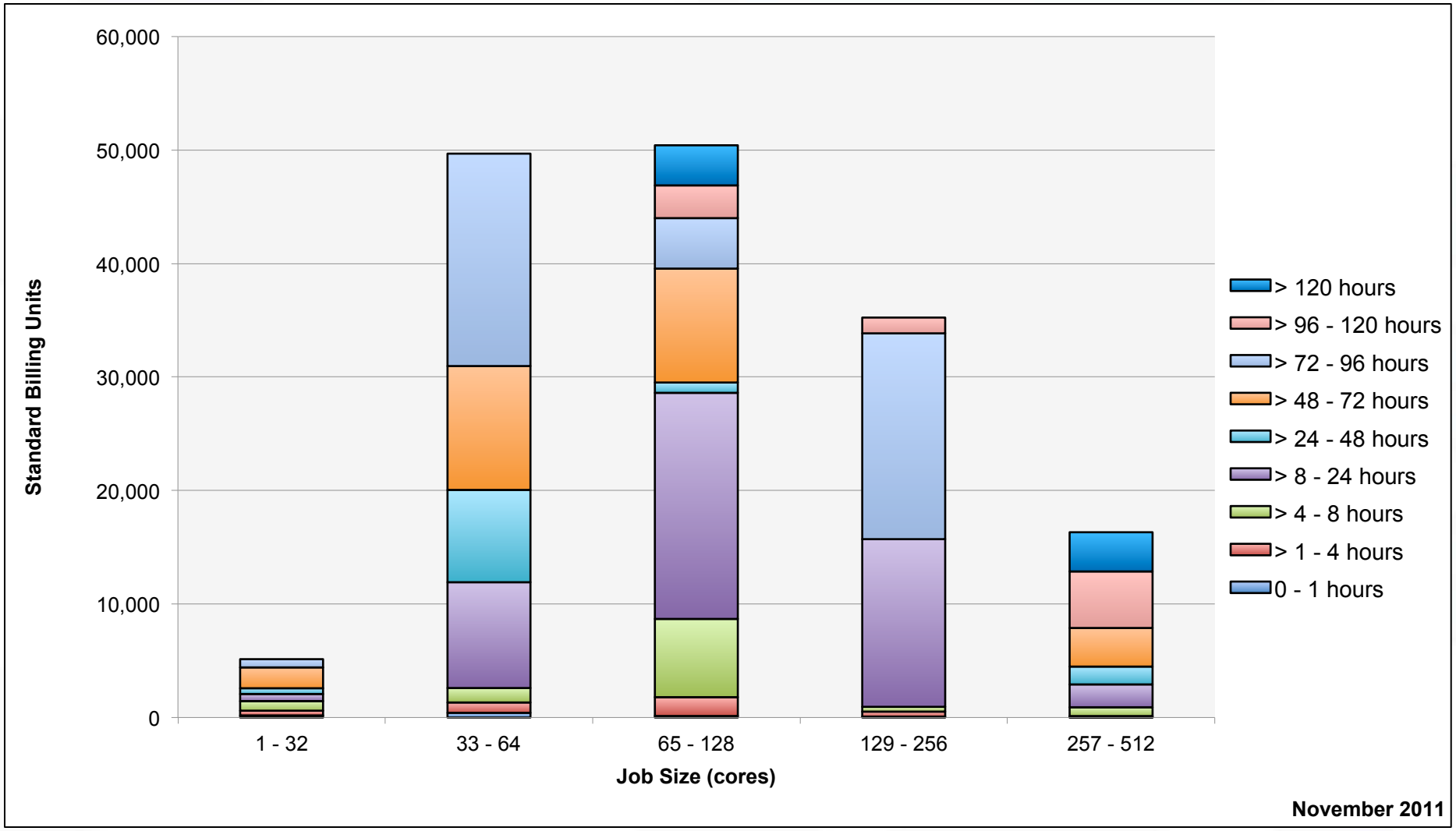
Columbia:
Monthly SBUs by Run Time



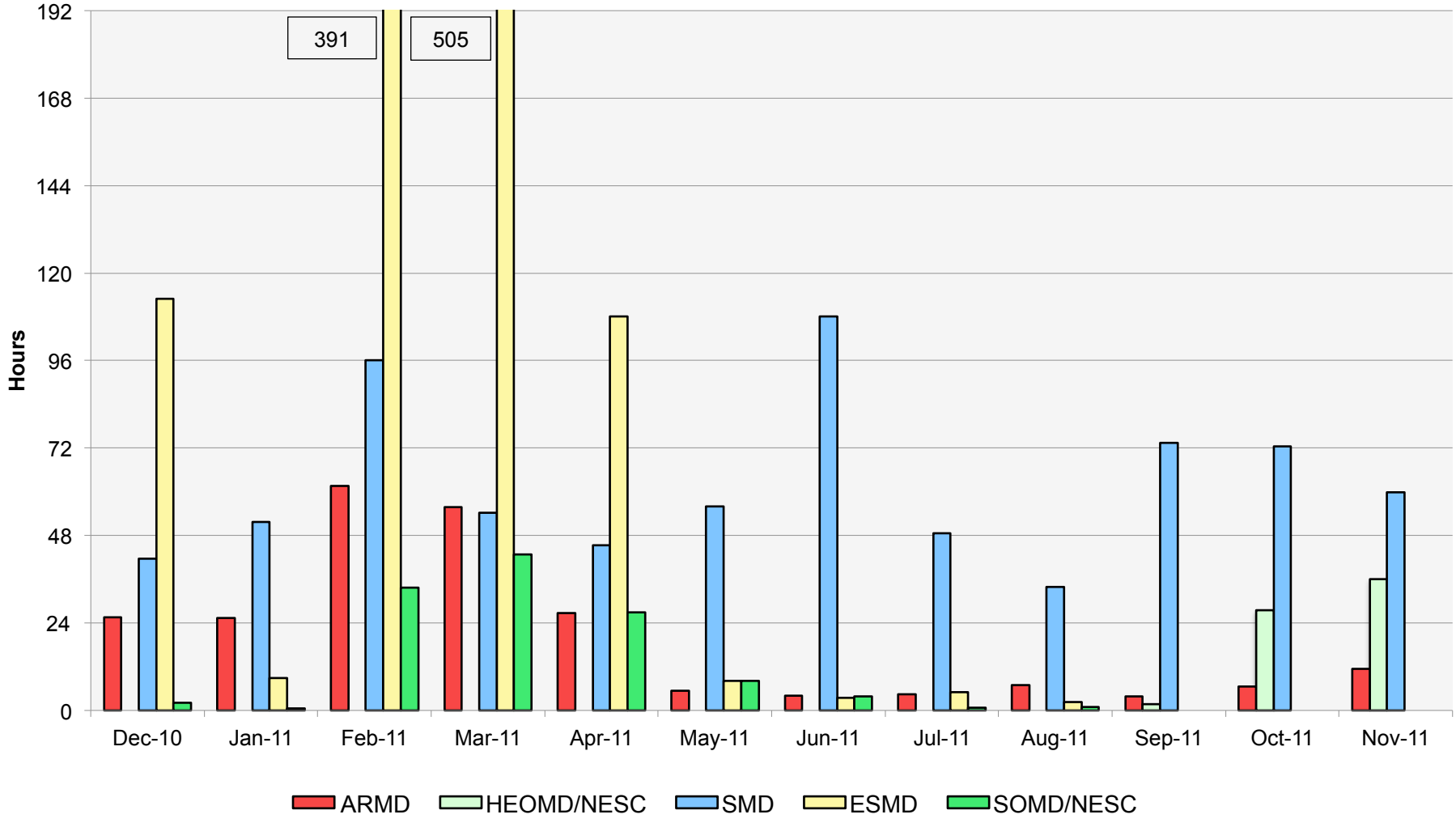
Columbia:
Monthly Utilization by Size and Mission



Columbia:
Monthly Utilization by Size and Length



Columbia:
Average Time to Clear All Jobs



Columbia:
Average Expansion Factor